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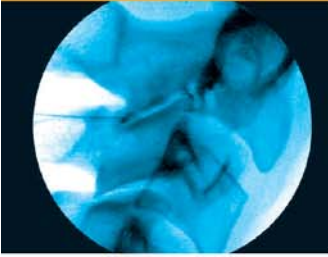
Sedation and pain management in interventional radiology

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Abstract

Administration of sedation and analgesia in interventional radiology is often necessary during painful diagnostic and therapeutic procedures and must be safe and comfortable for the patient. Non-anaesthesiologists performing sedation should be fully trained in the pharmacology of these medications, the physiology of sedation and analgesia, the monitoring of patients, airway support, ventilatory care, early and appropriate management of complications, and cardiopulmonary resuscitation. Although these agents are generally safe, catastrophic complications related to their use can occur, often as a result of incorrect drug administration or inadequate patient monitoring. Good sedation practice involves pre-sedation assessment and optimal selection of patients, careful monitoring and support from dedicated trained personnel in high-risk patients and adherence to recovery and discharge criteria.

Introduction

Interventional radiological procedures have increased during the past decades in number, complexity and importance. They have been valued by clinicians and patients because of their minimally invasive character and as an alternative to major surgical procedures. Nevertheless, as the patient is awake during the majority of these interventions, it is important that they feel the least possible distress. Apart from producing pain and discomfort, these procedures can also invoke fear and anxiety reactions,¹ rendering patients unable to follow breathing and movement instructions. Furthermore, increased sympathetic activity with tachycardia and hypertension has the potential to precipitate myocardial ischaemia or infarction in susceptible patients.² Patients undergoing these interventions often require sedation and analgesia to enhance procedural safety, comfort and success.

The recent proliferation of these procedures has increased the demand for sedation and analgesia. Proper use of analgesic and/or sedative agents improves

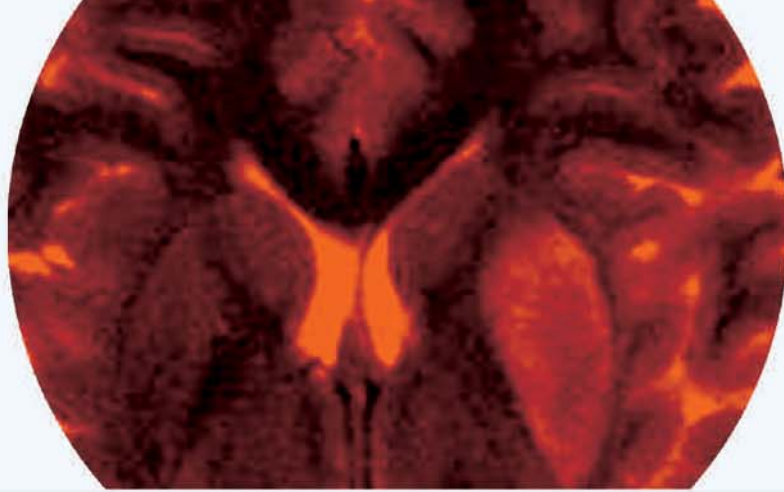
patient satisfaction, reduces procedure times and stabilises haemodynamic status. However, sedation carries significant risks for the patient, especially when inappropriate techniques are used by inexperienced or untrained personnel.³ Although anaesthesiologists are best equipped to administer sedation and analgesia, they are not usually available to attend all interventional radiological procedures. As non-anaesthesiologists are increasingly involved in sedation,^{4,5} it is crucial for them to understand safety considerations and to receive proper training.

This article will review the use of sedation and analgesia in interventional radiology, describe the different available pharmaceutical agents and outline factors affecting the safety of procedural sedation, including the performance and management of sedation and analgesia. The recommendations included in this review are primarily derived from practice guidelines outlined by the American Society of Anesthesiologists (ASA) task force on sedation and analgesia by non-anaesthesiologists and other guidelines published in medical literature.⁶

Definitions

Sedation refers to the use of pharmacological or non-pharmacological means to depress the central nervous system and reduce patient anxiety and irritability. Proper sedation achieves anxiolysis and in some circumstances, amnesia. The stages of sedation have been categorised in an attempt to define targeted endpoints for drug administration. However, the depth of sedation is not easily divided into stages but rather refers to a therapeutic continuum ranging from minimal anxiolysis to coma.⁶

The term 'conscious sedation' continues to be used in medical literature. However, this term is no longer included in the ASA Standards and its use should be avoided because it is imprecise and potentially misleading.⁷ Instead, the term 'moderate sedation' should be used. Moderate sedation is defined as a



minimally depressed level of consciousness that retains the patient's ability to independently and continuously maintain airway patency and respond appropriately to physical stimulation or verbal commands. It is produced by a pharmacological or non-pharmacological method or a combination of these (see Table 1).

- To minimise the risk of adverse events related to the procedure.

The pharmacological profile of the most commonly used drugs for the administration of sedation and analgesia is summarised in Table 2. The lower end of the dose range should be used initially to cater for inter-patient differences.

	Minimal sedation ('Anxiolysis')	Moderate sedation ('Conscious sedation')	Deep sedation	General anaesthesia
Responsiveness	Normal response to verbal stimulation	Purposeful response to verbal or tactile stimulation	Purposeful response following repeated or painful stimulation	Unarousable, even with painful stimulus
Airway patency	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular function	Unaffected	Usually maintained	Usually maintained	May be impaired

Table 1. Definitions of levels of sedation adapted from guidelines for sedation and analgesia by non-anaesthesiologists

The difference between analgesia and conscious sedation is the intent. With conscious sedation, the intention is to produce an altered mental state as opposed to analgesia. Sedation and analgesia are distinct processes: some patients require primarily sedation, some primarily analgesia provided by opioids or local anaesthetic agents, and some both of them. Painful procedures often require both sedation and analgesia because sedation alone in the presence of pain may cause confusion and restlessness. Non-painful procedures in uncooperative patients may require sedation alone. Drugs and techniques should be selected on a case-by-case basis according to the effect desired, procedural requirements and the needs of the individual patient.⁸ Medication should be administered in an attempt to achieve the following goals:

- To provide adequate analgesia, sedation, anxiolysis and amnesia during the procedure.
- To control unwanted motor behaviour that inhibits the performance of the procedure.
- To rapidly return the patient to a state of consciousness.

Drug name	Effects	Route of administration	Initial bolus dose (mg/kg)	Incremental dose (mg)	Onset (min)	Duration (min)	Remarks
Hypnotics							
Midazolam	Sedation, anxiolysis, amnesia, no analgesia	IV	0.05–0.1	1.0	2	45–60	May cause respiratory depression, reduced dose in hepatic dysfunction
		IM	0.1–0.15		10–20	60–120	
		Oral	0.5–0.75		15–30	60–90	
		Transnasal	0.2–0.5		10–15	60	
		Rectal	0.25–0.5		10–20	60–90	
Diazepam	Sedation, anxiolysis	IV	0.05–0.2	1–2	2–3	360	May cause respiratory depression
Propofol	Anaesthetic, sedation	IV	25–75 µg/kg/min infusion	1	3–5		May cause transient apnoea and hypotension
Ketamine	Analgesia, amnesia	IV	1–1.5	5–10	1–2	40–60	Lower dose if given with midazolam
		IM	4–5		3–5	90–150	
		oral	5–10		15–30	120–240	
Analgesics							
Fentanyl	Analgesia	IV	0.001–0.005	25 µg/dose Repeat every 3 min	2–3	20–30	May cause respiratory depression, nausea
Sufentanil	Analgesia	IV		2 µg/dose	2–3	15	
Remifentanyl	Analgesia	IV		0.1–0.2 µg/kg/min	3–5	5–7	May cause respiratory depression and hypotension
Morphine	Analgesia	IV	0.1–0.2	2	4–6	120–240	May cause respiratory depression, nausea
		IM	0.1–0.2		10–20	240–360	
Reversal agents							
Naloxone	Opioid reversal	IM	40 µg/dose Repeat every 2 min Maximum 2 mg		2	20–40	
Flumazenil	Benzodiazepine reversal	IM	200 µg/dose Repeat every 1 min Maximum 1 mg		1–2	30–60	

Table 2. Medications commonly used for sedation

Sedative dosage needs to be decreased in the elderly or sick patient and in those with organ dysfunction, highlighting the importance of pre-sedation assessment. For non-anaesthesiologists, a stepwise protocol should be used defining the initial, incremental and maximum dosage found to be safe and effective.^{9,10}

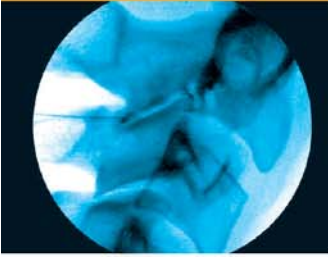
Pharmaceutical agents

Hypnotics and sedative drugs

Benzodiazepines produce a dose-related CNS depression. They cause anxiolysis, antegrade amnesia,

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hypnosis and have an anticonvulsive effect. They have no analgesic effects and, for this reason, they should be combined with opioids when analgesia is required in addition to sedation. The most commonly used benzodiazepines for sedation are midazolam and diazepam. Their short-acting sedative effects combined with rapid recovery and low risk of respiratory depression makes these drugs the favoured sedative agents for use by non-anaesthesiologists.^{5,9}

Hypnotic drugs like propofol and ketamine are intravenous general induction anaesthetic agents. At sub-hypnotic doses, these have good sedative and antiemetic properties. Propofol has no analgesic effects and is often combined with opioids, such as fentanyl. Propofol can rapidly cause apnoea even in low sedative doses and consequently current guidelines recommend that propofol only be used under supervision of an anaesthesiologist.¹¹ However, it has been shown that titrated doses of propofol can be used for effective sedation during interventional radiological procedures without inducing hypoxaemia or hypercapnia.⁵

Miscellaneous

Nitrous oxide has good analgesic effects and may be useful for short duration procedures. However, it must be used in well-ventilated rooms to avoid affecting the operator. Inappropriate use can lead to severe hypoxaemia and the risk of aspiration¹²

Chloral hydrate has long been used for paediatric sedation, although it has a long duration of action and residual effects are common. Motor imbalance, agitation and restlessness can occur after the patient is discharged home. Use is now restricted to children younger than 3 years of age.¹³

Other drugs like methohexital, thiopental and etomidate are potent drugs for inducing general anaesthesia. Their use by non-anaesthesiologists is not recommended.

Analgesics

Opioids are potent analgesics and have a sedative effect, but may cause dysphoria, nausea, vomiting and respiratory depression. These adverse effects limit their use to painful procedures in which analgesia is required. Fentanyl is a short-acting opioid and small doses may reduce the required doses of sedatives. Fentanyl is favoured over other opioids because of its rapid onset and suitable duration of action. Sufentanil is a short-acting opioid that is eight-to-ten times more potent than fentanyl with a similar onset of effect. Remifentanyl is a new opioid with a rapid onset which is administered by an infusion, titrated to the desired effect. Morphine is a long-acting opiate that is a sedative, anxiolytic and analgesic. Because of its longer duration of action, it is less suitable than a titratable and reversible agent.^{14,15}

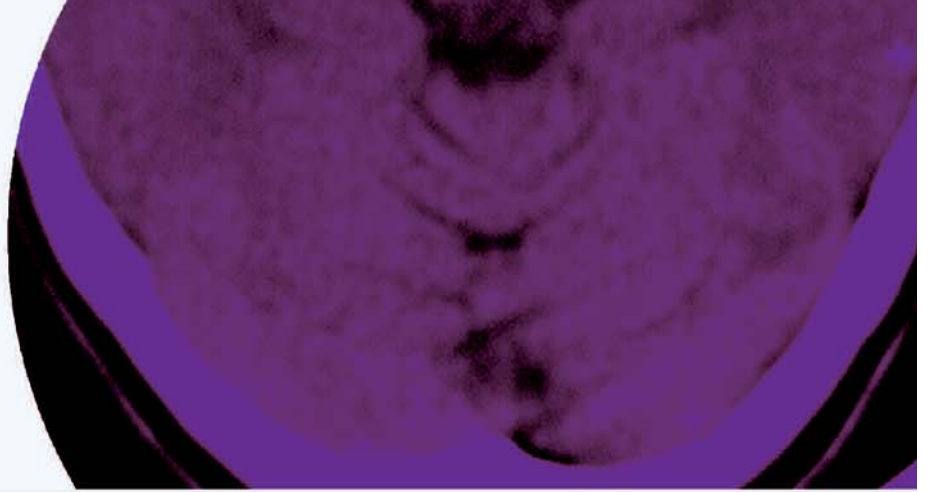
Reversal agents

These agents should be given in increments, waiting at least 1–2 minutes between each dose. Their use should be reserved for instances in which patients have inadvertently been sedated more deeply than was intended. Naloxone is an opioid reversal agent that reverses respiratory and analgesic effects. Because its duration of effect is shorter than that of some opioids, patients have to be closely monitored and repeat doses need to be given if mandated. Flumazenil is a benzodiazepine reversal agent. If administered, patients must be monitored for 2 hours to ensure that they do not become re-sedated.

Clinical use

Many different medications are available for sedation and analgesia during interventional radiological procedures and the drug or drug combination will vary depending on operator preference and skills. The following principles may help to ensure safe and effective use:

- Sedative drugs should be easily titrated to the desired clinical effect and should have a predictable onset and duration of effect with a rapid recovery.



- Intravenous administration is favoured because it results in a more reliable rate of onset.
- Each drug should be given in increments.
- Appropriate time intervals need to be left between increments to allow the drug effect to be evaluated before the next incremental dose or a different drug is administered.
- Drug combinations need to be used prudently and according to the required effect and patient response.
- Repeated increments need to be given throughout the procedure to maintain an adequate level of patient comfort.

Safety aspects

Staff and skills

All personnel responsible for the administration of sedation and analgesia and monitoring must be capable of recognising and acting on complications of over-sedation. Personnel should be capable of maintaining airway patency and assisted ventilation and it is recommended that advanced cardiac life-support skills be immediately available. Two qualified individuals must be present to ensure adequate care. The radiologist is responsible for overseeing drug administration and ensuring patient safety while a second trained person (e.g. a nurse) must be present to monitor the patient. The practice of a single operator providing sedation should be condemned. Physicians and medical personnel involved in sedation should undergo regular re-certifications of advanced cardiac life support. Staff should also receive training in the use of sedative drugs and in the appropriate monitoring and management of complications.^{6,9,15}

Equipment and settings

Appropriate equipment and drugs required for cardiopulmonary resuscitation and airway support should be available in the area where sedation is

conducted. In addition, adequate suctioning facilities, airway control devices such as endotracheal tubes and laryngoscopes, defibrillators and reversal agents should be available.

Monitoring and patient care

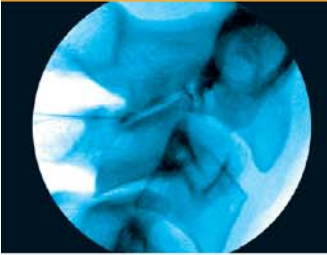
Monitoring during sedation is the key to a safe practice. All patients receiving moderate sedation should receive supplemental oxygen through nasal prongs or by mask and should have adequate venous access. Patients must be continuously monitored to assess the depth of sedation and to recognise signs of over-sedation. Vital signs (blood pressure, pulse, respiratory rate) should also be monitored continuously at appropriate intervals. Electrocardiographic monitoring should be used in patients with significant cardiovascular disease undergoing sedation. All patients should be monitored by pulse oximetry, although monitoring oxygenation is not a substitute for monitoring ventilatory function. Deeply sedated patients can hypoventilate and become significantly hypercapnic without becoming hypoxic if they are given supplemental oxygen. End-tidal CO₂ monitoring may detect respiratory depression sooner than pulse oximetry.¹⁶⁻¹⁸ Table 3 summarizes recommendations for monitoring during analgo-sedation in interventional radiological procedures.

Monitoring parameters	Comments
Vital signs Blood pressure (BP) Heart rate (HR) Respiratory rate (RR)	Recorded before and immediately after any drug administration 5 minute recommended interval until patient reached stable level, then every 15 minutes throughout procedure
Oxygenation	Measured continuously by peripheral pulse oximetry with appropriate alarms
Pulmonary ventilation	Must be checked visually or by auscultation Alternative end-tidal CO ₂ monitoring
Electrocardiography (ECG)	In all patients undergoing deep sedation and in patients with significant cardiovascular disease

Table 3. Recommendations for monitoring during analgo-sedation in interventional radiological procedures

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Post-sedation care

Patients continue to be at significant risk of developing complications related to sedation and analgesia following the procedure. Continued observation and monitoring should be carried out in an appropriate area until the patients are at their baseline level of consciousness. The following discharge criteria are recommended:

- Patients should have returned to baseline level of consciousness.
- Vital signs are stable within acceptable limits.
- Sufficient time should have elapsed following administration of reversal agents to ensure that patients do not become re-sedated.
- Outpatients should be discharged in the presence of a responsible adult who will accompany them home.

Non-pharmacological analgesia and anxiolysis

Non-pharmacological methods of analgesia and sedation such as hypnosis and anodyne therapy have

been successfully used in interventional radiology and have been shown to significantly reduce drug requirements. Furthermore, adjunct hypnosis is a cost-effective method during interventional procedures. Although the training of staff is reported to be relatively simple, the practice of using non-pharmacological methods is not yet widespread.¹⁹⁻²²

Conclusions

The safety and comfort of patients is the main priority in patient management. The provision of sedation carries the risk of potentially life-threatening complications and adherence to recommended guidelines is therefore mandatory. Choice of agents, techniques and personnel for proper care should be based on the specific needs of patients. To ensure the safety of all patients undergoing sedation and analgesia, training of staff and provision of support facilities for maximum patient care are also important.

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